Deep Learning

CSE 641

Learning Machines - Examples

- What are learning machines and how are they modelled?
  - Essentially a function mapping
- Binary Classification
  - Detection (Spam/no Spam; bomb/no bomb)

$$f(x, \alpha) : \mathbb{R}^n \rightarrow \{-1, 1\}$$

- Multi-class Classification
  - ADAS systems (pedestrians, vehicles, barricades,...)

$$f(x, \alpha) : \mathbb{R}^n \rightarrow \{0, 1, 2, \ldots, k\}$$

$$\alpha \in \Lambda$$

Some parameters governing the function *f*.
Can be abstract parameters like:
one or several thresholds
one or several hyperplanes
No. of neurons + weights

Learning Machines - Examples

- Regression
  - Predict [avg. enrolment in 2017, CGPA] based on [current enrolment, grade, job offer, package]

$$f(x, \alpha) : \mathbb{R}^n \rightarrow \mathbb{R}_+^m$$

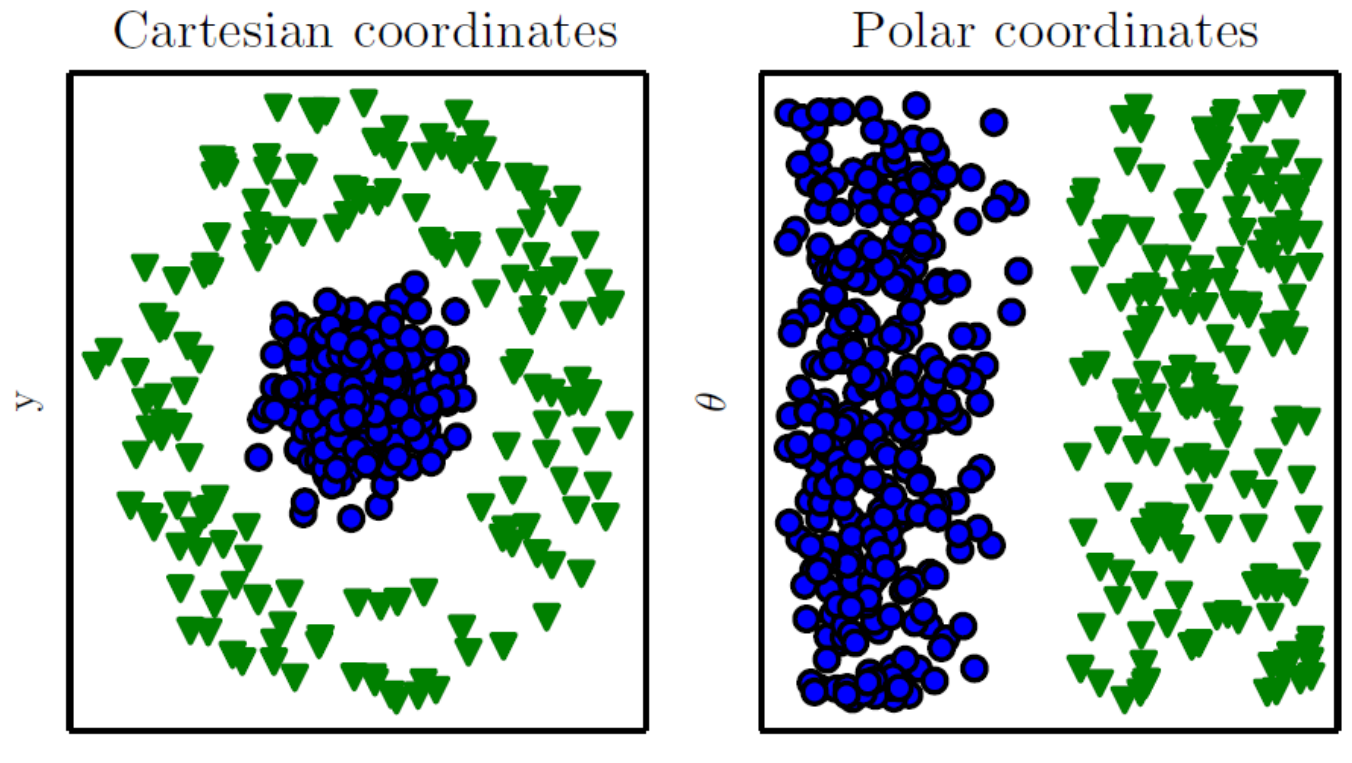
- Density Estimation

$$p(x; \alpha) : \mathbb{R}^n \rightarrow \mathbb{R}_+, \quad \int_{-\infty}^{\infty} p(x; \alpha)\, dx = 1$$

$$\alpha \in \Lambda$$

Some parameters governing the function *f*.
Can be abstract parameters like:
Degree of polynomial + coefficients
Mean, variance, skewness, etc.
Mixture of Gaussians
Mixture of heterogeneous densities (uniform + exponential)

Representations Matter

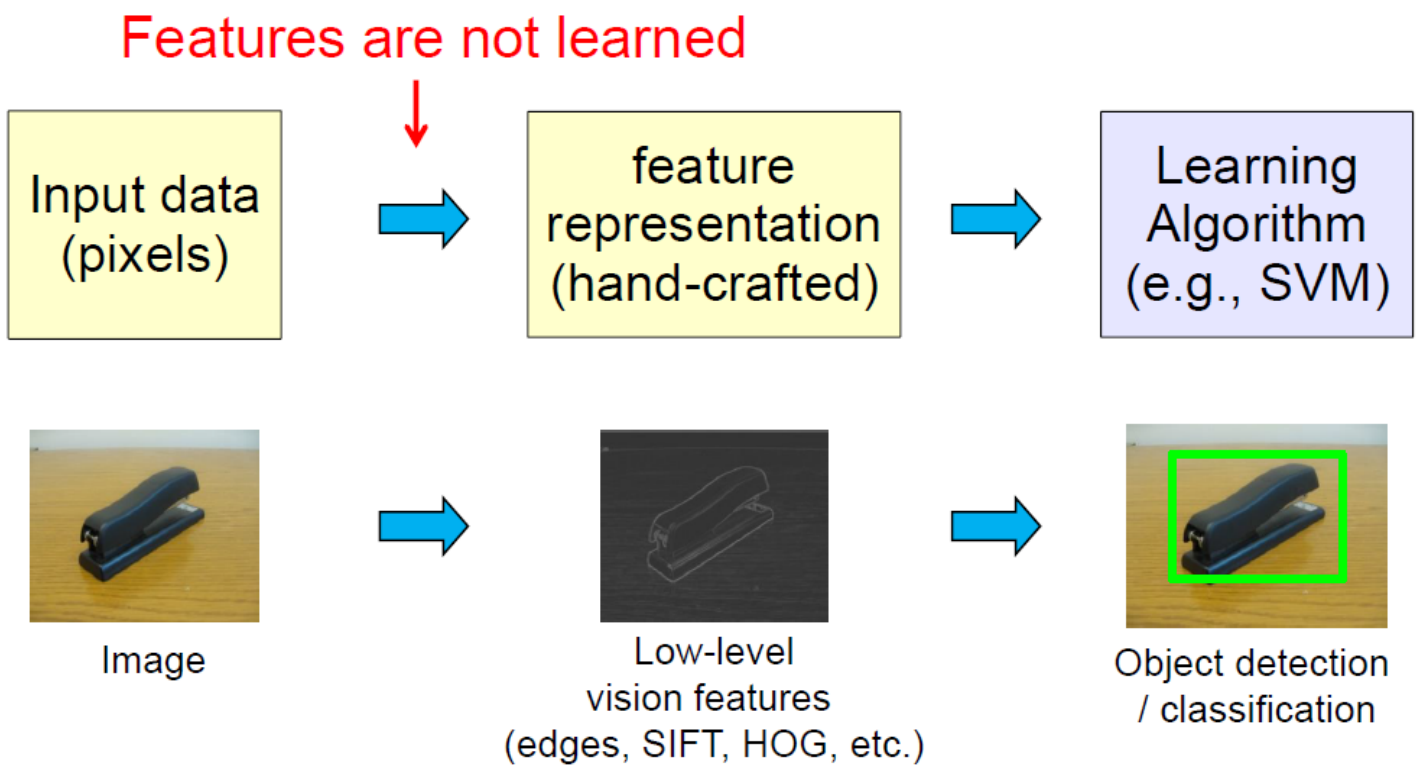


$f(x, \alpha) : \mathbb{R}^n \rightarrow \{-1, 1\}$

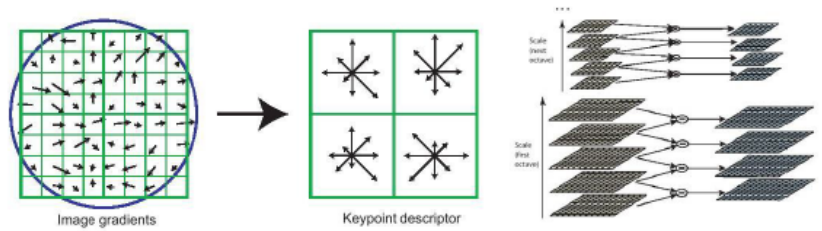
$f_1(x_1, \alpha) : \mathbb{R}^n \rightarrow \{-1, 1\}$

Figure 1.1

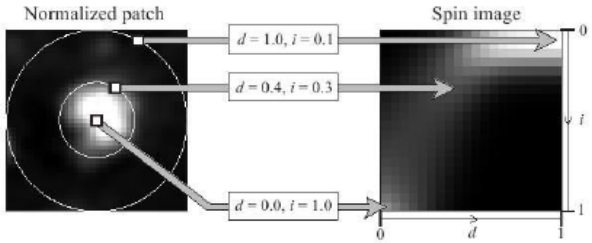
Traditional Recognition Approach



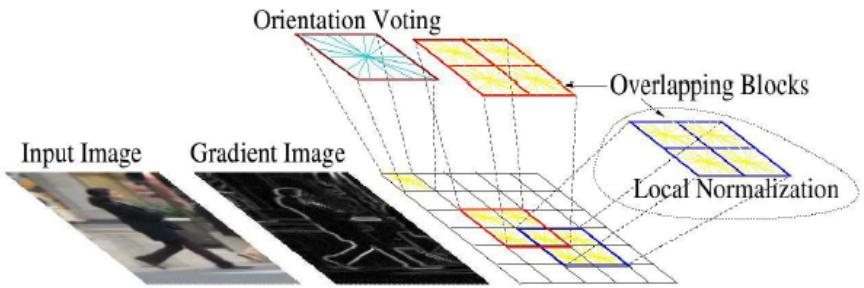
Computer vision features



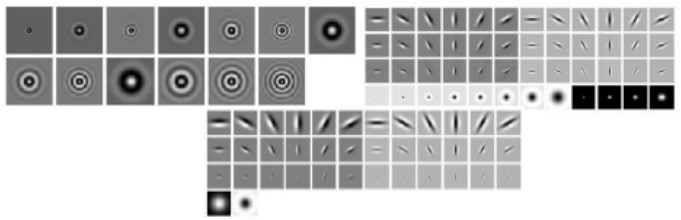
SIFT



Spin image



HoG



Textons

and many others:

SURF, MSER, LBP, Color-SIFT, Color histogram, GLOH, …..

Depth: Repeated Composition

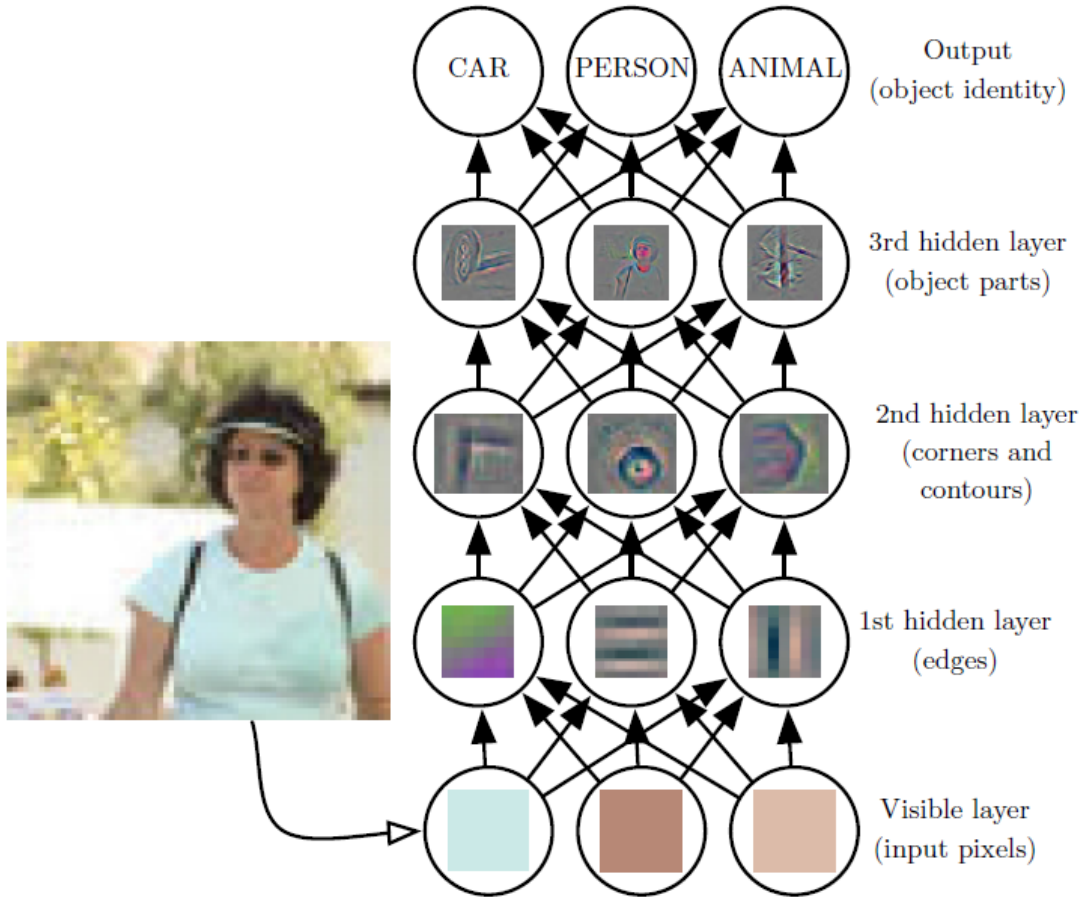


Figure 1.2

Computational Graphs

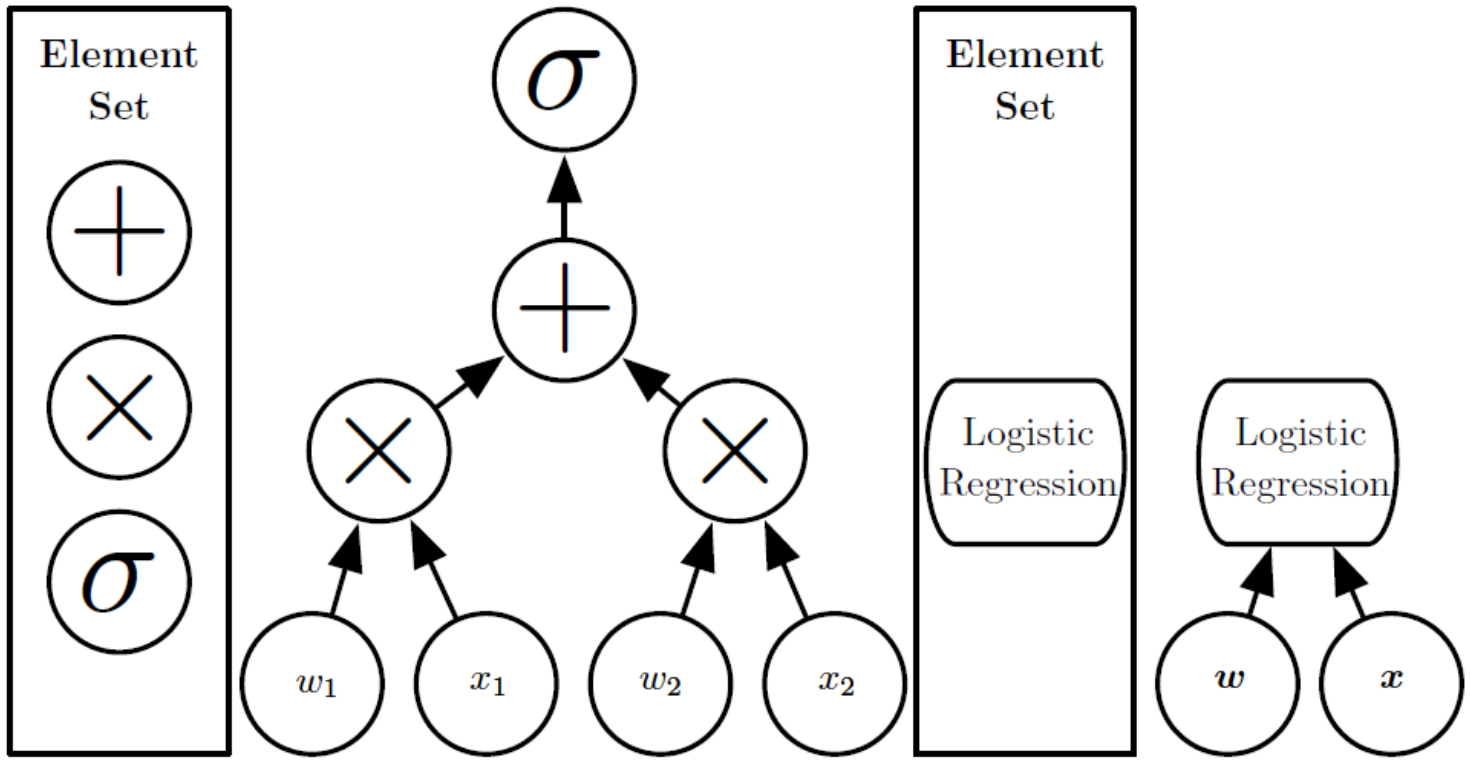


Figure 1.3

Machine Learning and AI

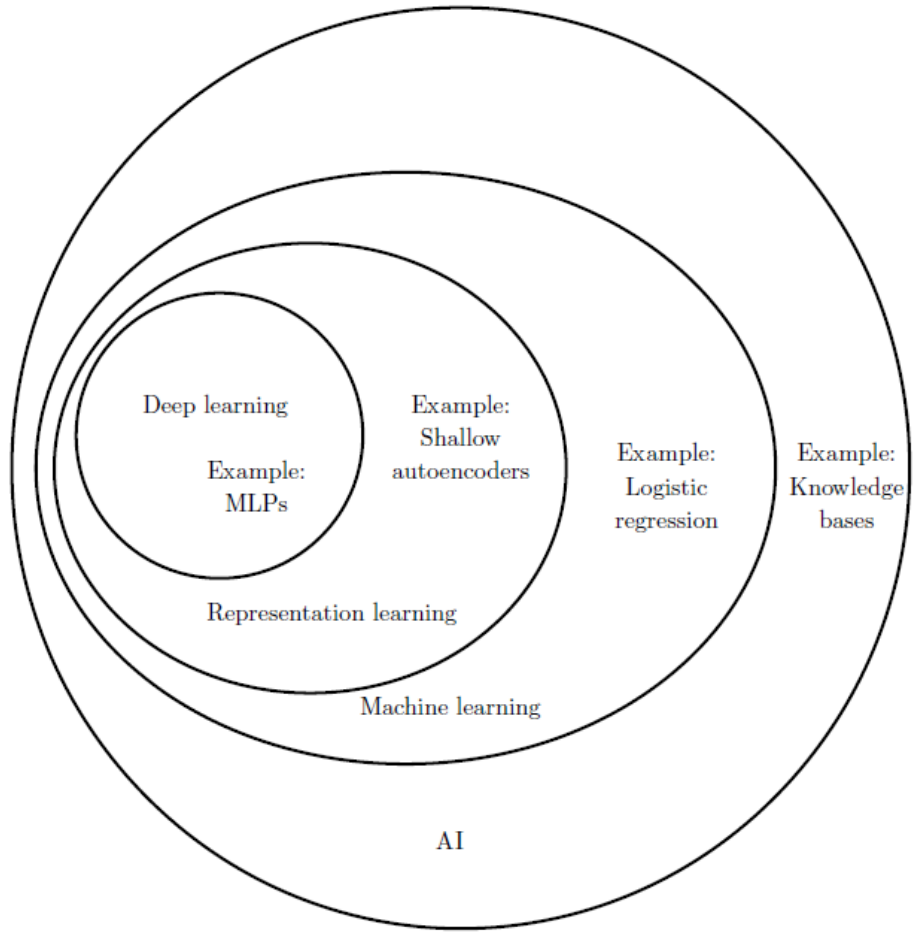
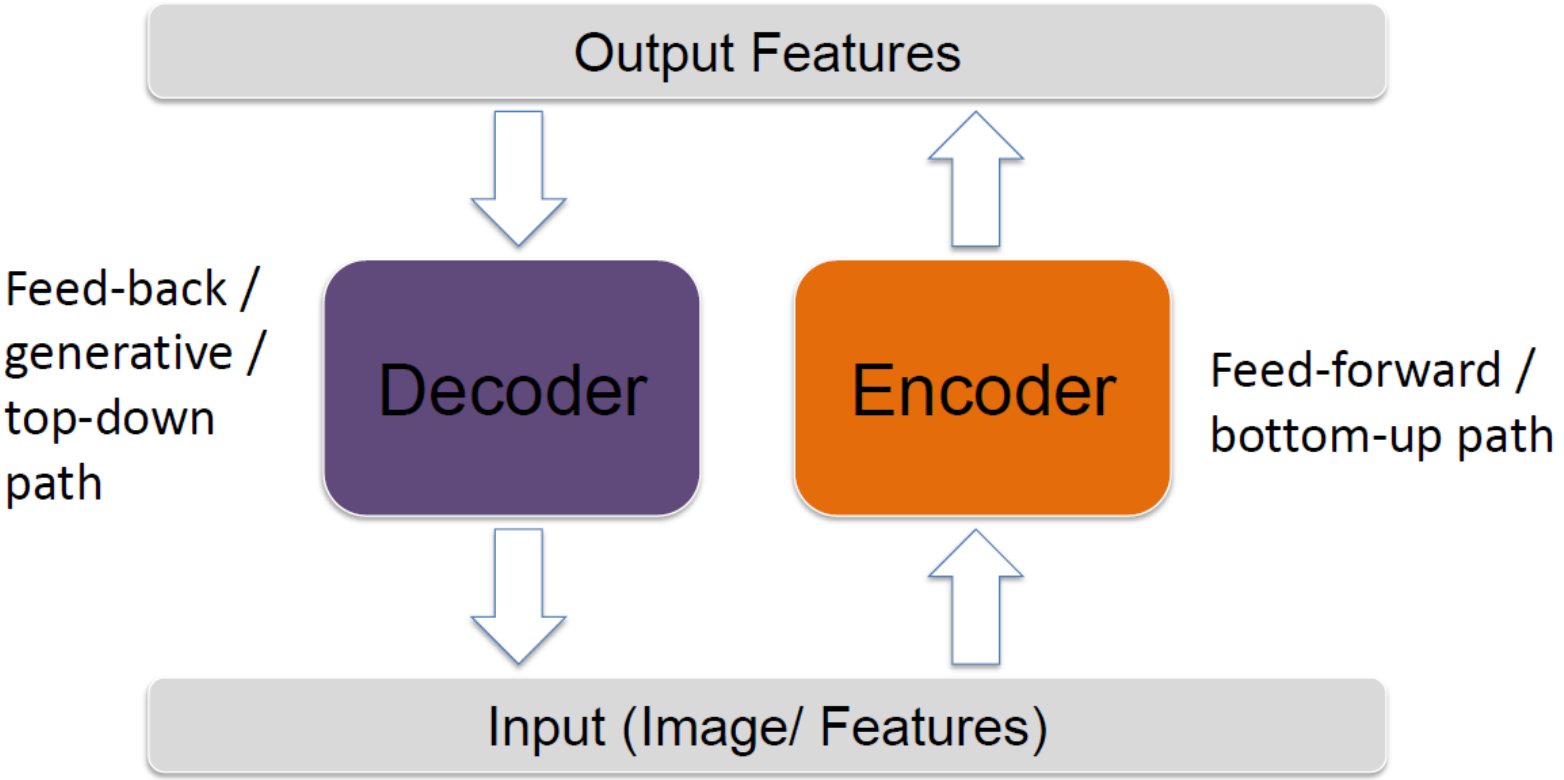


Figure 1.4

(Goodfellow 2016)

Representation Learning Example: AutoEncoders

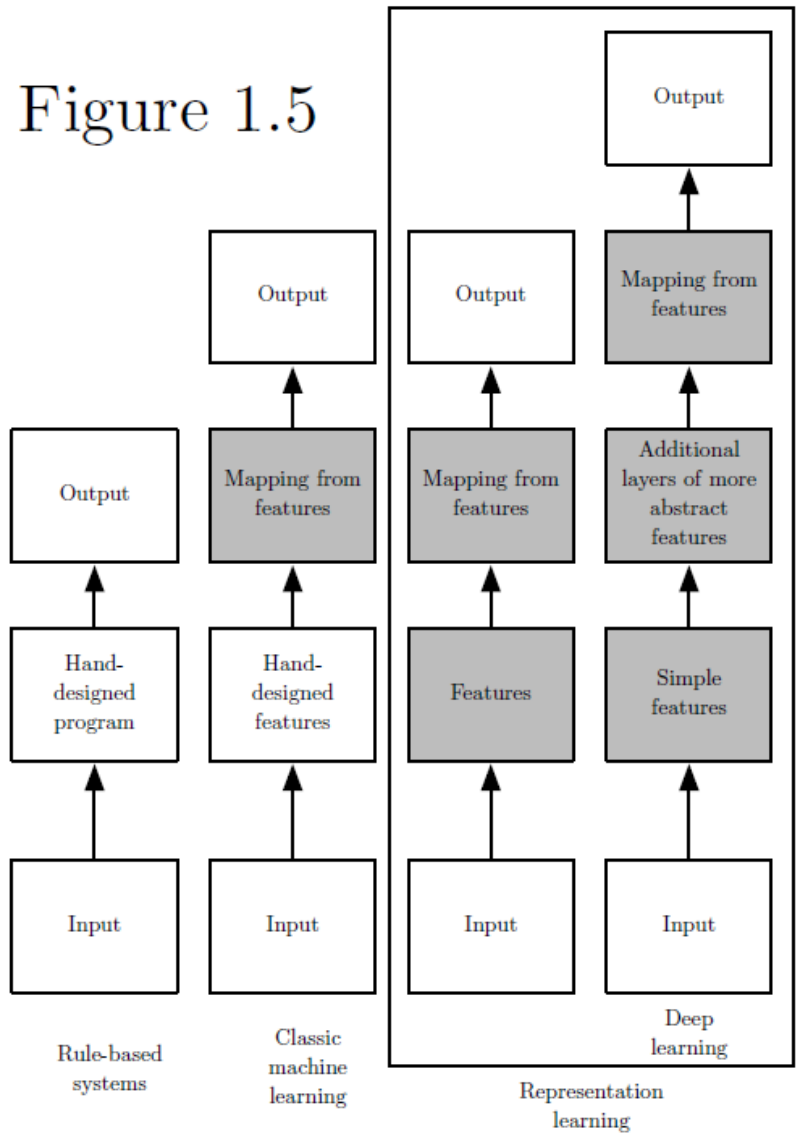


Bengio et al., NIPS'07; Vincent et al., ICML'08

Slide: R. Fergus

Learning Multiple Components

Figure 1.5



(Goodfellow 2016)

Course Administration

Required Prerequisites

- Machine Learning / Statistical Machine Learning
- Programming in Python
  - You will learn PyTorch in the Google Colab environment

Course Outcomes

- Understand various deep learning models such CNN, Autoencoders, RNN etc.
- Analyze various applications solved through the use of deep learning models
- Being able to design and implement their own deep learning models for the problem of their choice

- Course webpage:
  - Google Classroom: Deep Learning CSE 641
  - Class code: luia35e

People

- Instructors:
  - Dr. Saket Anand
    - Office Hours: Mondays 11:30AM-12:30PM, B-410 or by appointment

- TAs
  - Pravin Nagar
  - Shiv Kumar Gehlot
  - Shagun Uppal
  - Vishaal Udandarao

Reading Material

- Reference Books (for basics)
  - Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
  - Neural Networks: Tricks of the Trade - Second Edition

- Most reading material will be from research papers published in NeurIPS, ICML, CVPR, ICCV, INTERSPEECH, etc.

Tentative Schedule

- Convolutional Neural Networks
  - Architectures, Optimization and Applications (2 weeks)
- Optimization of Deep Networks (1 week)
  - Loss Functions & Optimizers
  - Practical Tips: Dropout, BatchNorm, Instance Norm, Group Norm, Spectral Norm, etc.
- Recurrent Neural Networks (2 weeks)
  - LSTMs, Attention, CNN-LSTM architectures
- Transformers (1 week)
- Autoencoders
  - Stacked and Denoising
- Generative Models (3 weeks)
  - Variational Autoencoders (VAE)
  - Disentangled Representations
  - Generative Adversarial Networks (GAN)
- Domain Adaptation and Transfer Learning (2 week)
- Other Applications
  - Metric Learning

Grading Scheme

- Form groups of three
- Each group works on Assignment and Project
- Relative Grading
  - More focus on improving accuracy / performance

Type of Evaluation	% Contribution in Grade
Assignment	20
Project	25
Quiz (2)	10
Class Participation	10
Mid-sem	15
End-sem	20

Operational Details

- Form groups of three in week 2
  - Choose wisely as the groups won’t change throughout the semester
- HW Assignments
  - Each topic will be accompanied with an appropriate task and dataset
- Class Presentations
  - Research papers will be provided every two weeks or so
  - Random calling of groups for 5 minute presentation per paper
  - Exam / Quiz questions could be based on assigned papers
- Course Project
  - Semester long project

Tentative HW Assignment

- HW-1 : CNN
  - Animal Detection / Traffic Light Detection
- HW-2 : RNN/LSTM
  - Image Captioning / VQA
- HW-3 : Variational Autoencoders
  - Generative Models + Disentangling
- HW-4 : GANs
  - Generative Models + Domain Adaptation
- Project
  - End-to-end deep network training for a problem of your choice